SCIENCE

VOL. 79 FRIDAY, MARCH 2, 1934 No. 2044

The American Association for the Advancement of Science:
Current Progress in X-Ray Physics: PROFESSOR DAVID L. WEBSTER 191

Scientific Events:
The British Department of Scientific and Industrial Research; The John B. Pierce Laboratory of Hygiene, at New Haven, Connecticut; The Eighty-seventh Meeting of the American Chemical Society. Recent Deaths 197

Scientific Notes and News 200

Discussion:
A Suggestion Regarding the Chemical Formulae of Compounds Containing Hydrogen and Oxygen Isotopes: PROFESSOR ROSS AIKEN GORTNER. *Para-Ortho Conversion of Deuterium:* ADALBERT FARKAS, LADISLAUS FARKAS and PAUL HARTECK. *Government Research:* PROFESSOR L. J. COLE. *The Law of Multiple Proportions:* DR. ARTHUR ROSE. *The United States Botanical Garden:* PROFESSOR F. A. VARRELMAN 203

Reports:
Memorandum on the All-union Institute of Experimental Medicine: S. S. GOLDWATER 206

Societies and Meetings:
The Western Society of Naturalists: DR. JAMES L. LEITCH. *The History of Science Movement in Washington, D. C.:* MORRIS C. LEIKIND 208

Scientific Apparatus and Laboratory Methods:
A Rapid Method for the Preparation of Delafield's Haematoxylin: H. W. NEILD. *Soap as a Mosquito Larvicide:* DR. JOSEPH M. GINSBURG. *Fixing the Print of Carbon Copies:* ALDEN F. ROE 209

Special Articles:
Deuterium Oxide and Aspergillus: SAMUEL L. MEYER. *The Effect of Ferric Chloride Injections in Experimental Tuberculosis:* DR. VALY MENKIN. *Frogs and Opalinidae:* PROFESSOR MAYNARD M. METCALF 210

Science News 10

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

CURRENT PROGRESS IN X-RAY PHYSICS[1]

By Professor DAVID L. WEBSTER

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INTRODUCTION

WHILE the title of this address covers a great deal of ground, it is really intended to limit the field rather than to widen it. Current progress in x-rays might well include the great advances in the application of x-rays to medicine, both in diagnosis and in therapy. Likewise it might include x-ray engineering. In that field there is rapid progress in the use of x-rays for testing engineering materials and also in the design and improvement of x-ray apparatus. While current progress in x-ray medicine and x-ray engineering are of vast importance, it is obvious that they can not be included in this address. Likewise, x-ray chemistry and mineralogy, by which I mean the use of x-rays in the study of the structures of molecules, either in fluids or in crystals, would take us much too far afield. I must therefore consider only topics that are clearly x-ray physics.

Even within this limit the field is far too large to be covered uniformly. So I shall illustrate the nature of current progress in x-ray physics by taking as an example a still more restricted field within it, namely, the physics of x-ray emission.

HISTORY

To bring out the significance of current progress in x-ray emission, let us first consider some familiar landmarks in its history. The most familiar of all, probably, is the famous series of spectra photographed by Moseley in 1913 and shown diagrammatically, with extensions to lighter and heavier elements than those used by Moseley, in Fig. 1, after Siegbahn. Moseley's spectra showed such a regular-

[1] Address of the retiring vice-president and chairman of the Section of Physics, American Association for the Advancement of Science, Boston, December, 1933.

ity of progression, from each element to the next, as to give the first definite proof of the importance of the atomic numbers. And the similarity of the spectra of the different elements was the first definite proof of the similarity of the structures formed by the inner electrons in all heavy atoms.

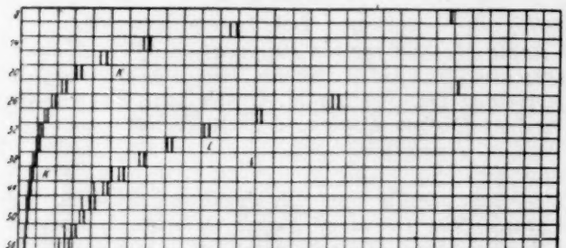

FIG. 1

Barkla, five years before Moseley's work, had found the x-rays from these same elements to be very regular in their properties. Moreover, he had come so near to the concept of atomic numbers as even to insist that the atomic weight given by chemists for nickel must be wrong, because nickel was out of order in the sequence of atomic weights, while its x-ray properties were just as regular as those of any other element. The factor that made it possible for Moseley to supplant atomic weights with atomic numbers was the increase of accuracy given by the Bragg x-ray spectrometer. And the factor enabling him to prove the similarity of the inner-electron structures of the elements more definitely than Barkla had proved it was the increase in resolving power for x-ray spectra, made possible by the same new apparatus.

And so it has been with x-ray spectra ever since. The next great advance was the long and careful series of researches by many physicists, especially by Siegbahn and his collaborators, extending Moseley's work in both directions along the scale of atomic numbers, and persistently improving the accuracy of the measurements, and attaining still higher resolving power to separate the lines into their components and to discover new lines.

In all this work, as in Moseley's first survey, the progression of each line from element to element was found to be very regular. Nevertheless, on careful theoretical analysis, some less regular aspects appeared. This happened when the frequencies of the lines were calculated as term differences, as in the optical series, and the term values were plotted against atomic numbers by Bohr and Coster, as in Fig. 2. Here the higher term values showed the same regularity of progression that Moseley had found for the line frequencies; but the graphs for the lower terms showed sudden changes of slope. These were interpreted in terms of changes in the structures of the atoms. More specifically, if we imagine ourselves building up a heavy atom by increasing the nuclear charge by a proton at a time, and letting new electrons fall in as they please, each bend in the graphs marks a point in the sequence of elements where the filling of some electron shell is completed and the next one begins. 57, for example, is the beginning of the rare earth group.

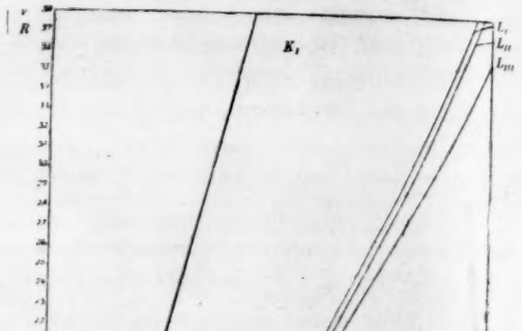

FIG. 2

To be sure, the bends in these graphs were not the only evidence we had on the filling of the shells. Chemical data and the spectroscopy of ordinary light confirmed these conclusions. But x-rays were one of the most important lines of evidence; and moreover, when any shell was once filled, it became buried under succeeding shells and got out of reach of chemistry or ordinary light; so for heavier elements we had to keep in touch with each buried shell by means of x-rays.

The regularity of Moseley's spectra, on which his discoveries depended, was apparent with measurements to 3 significant figures. The very slight departures from perfect smoothness, which were due to the outer electron shells and which enabled Bohr and Coster to distribute the electrons among them, became apparent with the next significant figure or

two. So naturally, one of the present lines of progress is toward still higher accuracy. All the strong lines are now listed to 5 or 6 significant figures, and a few even to 7. And on the theoretical side, our descriptions of the electron shells are being made more specific than mere numbers of electrons, as they take the form of wave-mechanical electron distributions.

CURRENT PROGRESS IN WAVE-LENGTHS

Research within the atoms, however, includes not only the determination of their structures, but other questions also. For example: Now that the electrons are placed, what holds them there? What forces act between them; or, if we must not talk of anything so anthropomorphic as forces, what relations exist between them, and what happens when you disturb these relations? For the outer electrons there are many lines of evidence on which to answer these questions; for the inner there are x-rays and other high-energy rays—all of them available in x-ray laboratories.

A continuation of previous wave-length researches, that ought eventually to yield much valuable information on these new questions, is the extension of x-ray spectra to longer wave-lengths. This development was given a great impetus only a few years ago by the discovery by Compton and Doan of a method of using ruled gratings for x-rays, instead of crystals. Where the longest wave-lengths attainable with crystals were around 20 or 30 Å, this new method, in the hands of Thoraeus and Siegbahn, Dauvillier, Osgood and others, has extended the spectra up into the hundreds of Ångstrom, where they merge gradually into the ultra-violet. In fact in this new region most of the lines would be classed at once as ultra-violet, but some others show the Moseley progression characteristic of the older x-ray region.

These spectra are of a type intermediate between x-rays and ultra-violet in other ways also. The spectra emitted by solids in this region show lines; but their lines are diffuse, and are thus intermediate between the sharp lines of the older x-ray region and the completely diffuse spectra of most solids in the visible. And in theory also these lines are intermediate between ultra-violet and x-rays, being due to transitions between the outer electron states, familiar to students of the ultra-violet, and the inner ones associated with x-rays. Eventually these spectra ought to tell us a good deal about such transitions, when their theory catches up with experiment.

Another field of wave-length researches is on a large class of lines in the older x-ray region, called non-diagram lines because they are not in the diagrams of spectral terms by which Bohr and Coster made their great advance in the theory of atomic structures. To see the significance of the non-diagram lines, let us first take a closer look at a Bohr-Coster diagram for a single element, for example, the one for tungsten as replotted by Siegbahn and shown in Fig. 3. This is obviously a Grotrian diagram for a system of doublets, much like those of the optical spectra of the alkali metals. The S terms are in the left-hand column, the P's next, then D's and F's, as usual. The chief difference is that it is inverted, in the sense that here the electron shell nearest to the nucleus, namely, the K, appears at the top of the diagram rather than the bottom. The reason for this, however, is simply that the energy represented by the point K is not energy given to the atom by putting an electron into the K shell, but by taking one out of it. Placing K at the top, therefore, simply means that it takes more energy to take an electron out of the K shell than out of any other.

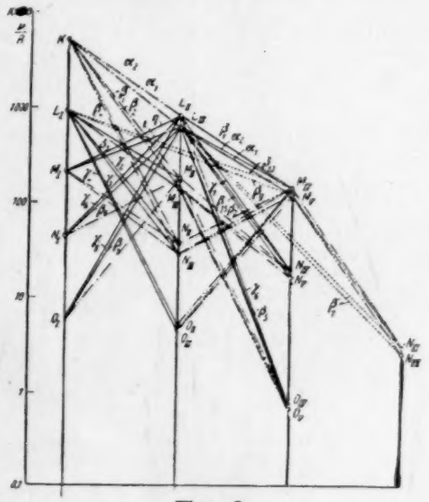

FIG. 3

With this fact in mind, the line drawn downward from K to L_{II}, for example, indicates a release of energy when the atom changes from a state of K ionization to L_{II} ionization, while the actual electron transfer is in the other direction, an L_{II} electron dropping into the K vacancy.

By the usual selection rules, taken over from optical spectra, every electron transfer ought to go between adjacent columns, changing the azimuthal quantum number by ± 1. And evidently most of them do so. In a few cases, however—and these constitute a limited class of non-diagram lines—the change is by 2 units. We have here, for example, the transitions from L_I to M_{IV} and M_V; and the transition from L_I to M_V, as a matter of fact, changes the inner quantum number also by 2 units. The first two non-diagram lines of this class were found as long ago as 1916, by Dershem, and such lines have often been explained as quadrupole radiation; but it is only recently that this explanation has taken a quantitative form, in the hands of Segré. This advance is a good confirmation of some fundamental

postulates of the theory of radiation, which predict that quadrupole radiation should be more prominent in x-ray spectra than in ordinary light.

Another class of non-diagram lines are some components of the very strong diagram lines, discovered by van der Tuuk, in such elements as iron, in which the valence shells are incomplete and have high multiplicities. Apparently these lines are caused by coupling between the valence shells and the x-ray shells. This coupling changes x-ray levels from doublets to higher multiples of a peculiar sort, looking like doublets with low resolution, but having each term widened or split when the resolution is increased. These multiplets ought eventually to give valuable information on the coupling between these shells.

Most of the non-diagram lines, however, can not be explained at all in terms of these energy levels; and while some of them were discovered by Siegbahn and his collaborators as far back as fifteen years ago, there are still many new non-diagram lines being discovered every year. To explain them, there are at present two theories. One, due to Wentzel, is that any such line is due to ionization of two inner electron shells at once, followed by a single electron transition like that of one of the diagram lines. The other theory, due to Richtmyer, is that such a line results from a different sort of double ionization, involving an inner shell and an outer one, followed by a two-electron jump filling them both. Wave-length measurements are adduced by the advocates of both theories as confirmatory evidence, without as yet reaching an agreement either way.

Intensities

Wave-lengths, however, are not the only data obtainable from a line spectrum. Other data of coordinate importance are the intensities of the lines. From the theoretical aspect, just as wave-lengths tell us about electrons in their stationary states, intensities tell us about their transitions. As noted already, we now have a great deal of accurate information about the stationary states, but our knowledge of electron transitions is still very incomplete. This difference, indeed, is due primarily to a corresponding difference in the accuracy of present data on wave-lengths and intensities: wave-length data now call for 7-place logarithms, but intensities have not yet graduated from the slide-rule class.

At that, however, intensity measurements have already accomplished a great deal. In their most rudimentary form, that of merely looking at spectrograms and seeing which lines are strong and which are weak, they established some very fundamental laws, notably the selection rules. The advance of intensity research from rough estimates to real measurements was made first by W. H. Bragg and W. L. Bragg, when they measured the intensity ratio of the $K\alpha$ doublet of rhodium, which is like that of tungsten, shown as the transitions K-to-L_{II} and K-to-L_{III} in Fig. 3 (p. 193). This ratio they found to be 2-to-1, like the doublets in the optical spectra of the alkali metals. Further measurements of line intensity ratios, by Duane and his collaborators, and by S. K. Allison, Jönsson and others, revealed other extensions of the optical sum rule to the x-ray series. But there are some notable exceptions. For example, there is a doublet in the L series corresponding exactly to $K\alpha$, namely L_{I}-to-M_{II} and L_{I}-to-M_{III}. This doublet has apparently just as clear a reason to be 2-to-1, but its intensity ratio is actually nearer 3-to-2 in the elements for which it has been tested. In many measurements of line intensity ratios there are great difficulties of technique; but in the hands of Allison, von Hevesy and many others this field is making rapid progress.

On the theoretical side, intensity ratios present many unsolved problems. For the diagram lines these appear to be largely problems of quantitative calculation and on them notable progress has been made recently by Pincherle. For the non-diagram lines, however, aside from the quadrupole lines and van der Tuuk's higher multiplets, even the underlying principles are in doubt, because we do not know whether to ascribe these lines to Wentzel's double ionizations followed by single electron jumps or to Richtmyer's double jumps. As Druyvesteyn and others have shown, Wentzel's theory agrees with experiment on many points about intensities as well as wave-lengths. On the other hand, one of the most serious obstacles to this theory comes from the intensity field, in a measurement of the excitation potential of one of these lines in copper, by DuMond and Hoyt, that seems definitely to prove the excitation potential too low for the required double ionization. Nevertheless, Richtmyer's double-jump theory also has its obstacles in the intensity field, among them being a theoretical one found by Langer, that the interaction energy of the two jumps appears too low to predict double-jump lines of observable intensity. Altogether, it seems still too early to decide between these theories. Possibly both may be correct, some lines being explained by Wentzel's theory and others by Richtmyer's.

These researches just reviewed all relate to ratios of intensities of different lines and therefore give information on the ratios of the probabilities of their different transitions. There is, however, another type of intensity research, with another objective. This is on the intensity of any one line as a function of the voltage on the x-ray tube. Its objective is to test the laws of interaction of atomic electrons and cathode

rays. More specifically, as the voltage on the tube increases, the intensity of any x-ray line changes in proportion to the number of atoms ionized in the inner shell responsible for that line. In measuring the intensity of any line as a function of tube voltage, therefore, one measures the probability of impact ionization of an inner electron shell as a function of the kinetic energy of the cathode ray before the impact.

Similarly in the continuous emission spectrum, the intensity at any given wave-length, considered as a function of tube voltage, measures a probability of interaction. But while the interaction measured by a line intensity is an ionizing interaction, between the cathode ray and an atomic electron, that measured by the continuous intensity is a radiating interaction, between the cathode ray and the atomic nucleus.

Considering either of these intensities as a function of cathode-ray energy, for directness of theoretical interpretation all the impacts involved in any one measurement must of course occur at the same energy. This condition, however, is never satisfied in a thick block of metal, such as we generally use as a target for cathode rays, but only in an extremely thin film. Measurements with such extremely thin targets involve special techniques of various sorts, and were first made about 5 years ago by several observers independently; for continuous spectra by Duane, by Kulenkampff and by Nicholas; and for line spectra by Clark, Hansen, Yeatman, and me, and by Lorenz.

In spectra of both types, the theories then available were found to be definitely incorrect. For continuous spectra, rapid progress in the theory was then made by Sommerfeld, Sugiura and Eckart, all using wave mechanics. In Fig. 4, for example, we have some theoretical graphs plotted by Sommerfeld, with experimental points from Kulenkampff's data. The ordinates here are continuous-spectrum intensities from a thin target of aluminum, all for the same wave-lengths but for rays emitted in different directions. The graph marked "40°," for example, is for rays emitted at 40° from the direction of the cathode rays; and the other graphs relate to other directions in the same way. In all these graphs, the abscissas are tube voltages, or cathode ray energies, the left end of the scale being the excitation voltage of the wave-length used. In each graph, the first experimental point was known to be much too low, because the resolving power was not sufficient to exclude some wave-lengths excited only at higher voltages. Neglecting these first points, however, the decrease of intensity with increasing voltage is represented by Sommerfeld's theory much more exactly than by any previous one. In other respects, also, this theory compares very favorably with Kulenkampff's measured intensities; and on polarization such parts of it as have yet been tested are confirmed, at least approximately, by Duane, Kulenkampff, Ross and Cheng.

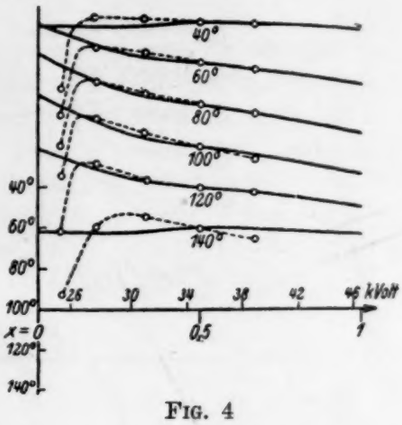

FIG. 4

While these continuous-spectrum intensities measure probabilities of radiating interactions between cathode rays and atomic nuclei, the line intensities, as noted above, measure ionizing interactions between cathode rays and atomic electrons. And here also, much progress has been made since the first thin-target work of five years ago. The next measurements of these interactions, as a matter of fact, were not made by x-ray methods, but by direct measurements of ionization in gases. Among these I should like to call attention especially to some data on helium, since helium contains only one electron shell and is therefore especially simple in theory. Some of the results for helium are shown in Fig. 5. The continuous graphs here represent theoretical equations, while the data shown by the dots are a part of a series running well above the range of voltage covered by these theories, and were taken by P. T. Smith in 1930. The abscissas are voltages, or cathode-ray energies, expressed in terms of their natural unit, the K ionizing potential V_K. The ordinates are probabilities of ionization, or equivalent effective cross-section areas, also expressed in terms of a rather natural unit, the area $\frac{2\pi e^2}{V_K{}^2}$.

The contrast between the theories shown here is obvious. The classical theory is very far from the data, even though it takes account of all the significant factors known to classical quantum theory, such as the orbital motion of the atomic electrons before impact and the effects of nuclear attractions, both on the atomic electrons and on the cathode rays. On the other hand, Massey and Mohr's theory, and Wetzel's, both of which are based on wave mechanics, are really good approximations.

For ionizing cross-sections taken from line intensities, in the x-ray region, Fig. 6 shows some data on silver obtained recently by Hansen, Duveneck and the

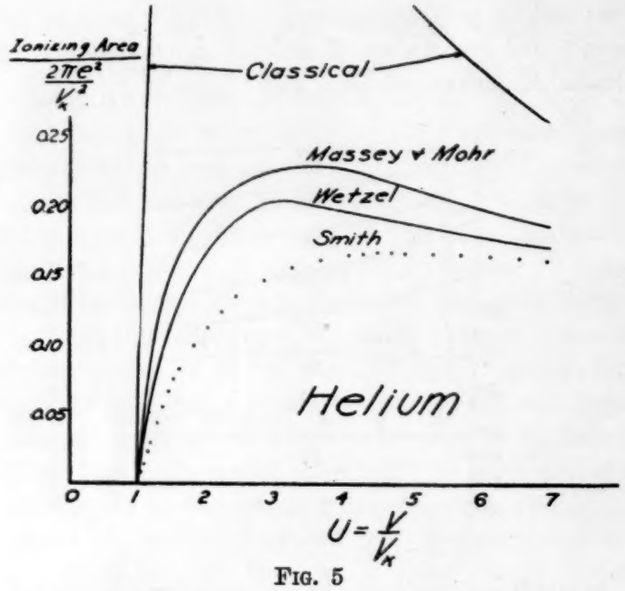

FIG. 5

author. The atomic electrons here are those of the K shell only, as in helium. The significance of the abscissas and ordinates are also as in the helium graphs, except for the fact that the ionization probabilities, or areas, are expressed here in arbitrary units, equating the theoretical values to the experimental at the highest voltage. This procedure is adopted because the absolute values are not known so accurately for silver as for helium. All the theories, however, predict that they would be about a million times smaller for silver than for helium, because their natural unit ($2\pi e^2/V_K^2$) is that much smaller; and recent data taken by J. C. Clark confirm this prediction. So the units of the graphs on this slide are probably not very seriously different after all.

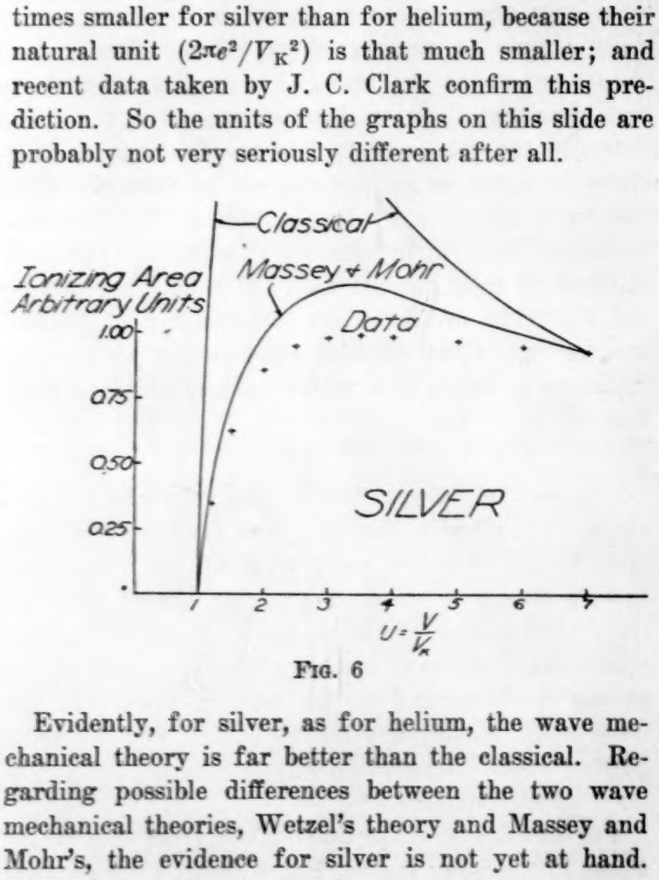

FIG. 6

Evidently, for silver, as for helium, the wave mechanical theory is far better than the classical. Regarding possible differences between the two wave mechanical theories, Wetzel's theory and Massey and Mohr's, the evidence for silver is not yet at hand. Both of these theories require very laborious computations, and I wish to express here my most cordial thanks to Professor Wetzel for starting such computations on his theory, as well as to Professor Massey and Mr. E. H. S. Burhop for actually obtaining the figures for the graph we have before us.

For electrons in shells other than the K, some data have been obtained by Coster and van Zuylen on the L electrons of tungsten, and by Pockman, Kirkpatrick and me on those of gold. The general character of the interactions of these L electrons with cathode rays is much like that of the K electrons, though they differ quantitatively, both from the K electrons and among themselves. These differences would be quite inexplicable by any classical theory; but Goldstein has shown that wave mechanics predicts differences, though whether it predicts them correctly is one of the numerous questions that still lie before us.

In short, this branch of intensity research is now at a stage of evolution that wave-length research had reached about fifteen years ago, when the Ritz combination principle had just been extended to the inner electrons, but nobody knew how many electrons there were in each orbit. For intensities, now, the wave mechanics has just been extended to the interactions of the inner electrons with cathode rays, at least as a good first approximation, but the theory is by no means complete. To date it is based on the first term of Born's perturbation series, with the second considered only in purely qualitative corrections by Massey and Mohr. Much development is therefore needed there. And while the data for silver and helium are much alike, their differences will give us valuable information. The effects of relativity should be much greater in silver than in helium; and also silver contains other electrons, outside the K shell, which must exert an influence, both by the screening effect and by changing the system of orthogonal functions with which one must calculate. Thus the differences between these elements or with others to be tested later will be most significant as a test of the way in which the wave mechanics handles the problems of relativity and of many electrons. Since the contrast between wave mechanics and classical theory is especially great here, and the data decide so clearly between them, it is reasonable to expect such data to be of still further use as a proving ground for theories attempting greater accuracy.

Indeed, considering the broader field of x-ray emission as a whole, it is evident that intensity measurements have a great deal to tell us about the interactions of electrons with one another and with nuclei, and their story has only just begun.

THE REST OF X-RAY PHYSICS

The progress in the physics of x-ray emission, which I have just sketched in outline, is typical of

x-ray physics as a whole. Absorption, refraction, scattering, the Compton effect and other branches of x-ray physics present the same variety of researches, ranging from extreme refinements in the study of familiar phenomena to preliminary explorations of new ones.

The most unexplored field in all x-ray physics, however, lies in the direction of extremely high voltages. Coolidge, Lauritsen, Tuve, Lawrence, van der Graaf and their collaborators have already shown the way to this new field and found plenty of new rays there. Thus far, the new rays are all of one type, continuous spectra. But with what we now know of nuclear excitations and disintegrations by positive rays and of nuclear excitations at least by beta rays, there is no telling what may be found in this new field.

Altogether, x-ray physics includes not only the old field of wave-length research, now pushing on from its fifth significant figure to its sixth and seventh, and such newer fields as intensities, now trying for the second or third figure, but even such a very new field as this one of high voltages, where the first figure is still unknown.

SCIENTIFIC EVENTS

THE BRITISH DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

ACCORDING to the annual report of the British Department of Scientific and Industrial Research, issued recently, the grant of £1,000,000 made by the government in 1917 for the encouragement of industrial research has become exhausted. The fund has been used by the department for assisting the formation of cooperative research associations in various industries, maintained partly by grants from the department and partly by subscriptions from industry. Though the "million fund" is no longer available the department's grants are now being made from its parliamentary vote.

A large part of the report of the Advisory Council of the department, signed by Lord Rutherford, is devoted to a survey of the research association scheme and to summarizing the results of the experiment. The expending of the million fund has attracted a total industrial contribution of £1,750,000, and at the moment the state is contributing £65,000 a year and industry £170,000 a year towards the support of a group of nineteen research associations, which include in their membership some 5,000 firms.

Striking examples are quoted to illustrate the enormous savings that have accrued from research work in various large industries. The report points out that the annual sum of less than £250,000 is trivial in relation to the interests involved and the possibilities awaiting realization. The basis on which many of the research associations are working is said to be hardly commensurate with the size of the industries they serve.

Work in progress is carried on in the department's own establishments and in the laboratories of research associations. For example, work in progress at the Department's Building Research Station includes the study of the most economical means of warming a house, investigations on wall plasters, on the problem of damp walls, on painting on cement and plaster, and on the deterioration of bricks.

The work of the Food Investigation Board of the Department is said to be meeting with considerable success in improving the quality of foodstuffs and in eliminating waste by better methods of transport and storage.

The Wool Industries Research Association has found a new process for making wool unshrinkable by the treatment of the wool fibers in bulk before they are spun.

Work for the automobile industry included research on the problem of cylinder and piston wear, which involved 360 distinct engine tests and 15,000 measurements. Besides this work, the Research Committee of the Institution of Automobile Engineers is carrying out investigations on the wear of valves and valve-seats, big-end bearing problems, lubricating oil pumping, and oil consumption. During the year the responsibility for road research has been transferred to the department from the Ministry of Transport. Researches on road tars are being carried out at the Chemical Research Laboratory. Work on motor-car headlights at the National Physical Laboratory has led to a method for determining the light distribution which should be aimed at for a headlight beam.

The report states that many of the researches of the department have a direct bearing on public health. Chief among these is the work of the Water Pollution Research Board on water supplies and the prevention of pollution. A complete survey is being made of existing knowledge regarding the solvent action of water on lead. The effect of electric currents in leaden waterpipes on the lead content of the water is also being investigated. Work is also being done on water-softening processes.

At the request of the Home Office, the department has arranged for an investigation to produce more efficient respirators for use in industrial processes as a protection against the inhalation of dust.

Research is also being carried out on the detection of small quantities of toxic gases in the atmosphere, and on respirators to prevent the breathing of such gases.

The improvement of materials used in dentistry is also a subject of research under the department, while x-ray examinations have been carried out in cooperation with the Medical Research Council on the structure of teeth.

THE JOHN B. PIERCE LABORATORY OF HYGIENE AT NEW HAVEN, CONN.

UNIQUE facilities for the study of the effect of a wide variety of atmospheric conditions on the health and comfort of human beings and animals have been provided through the completion of the John B. Pierce Laboratory of Hygiene at New Haven, Conn., according to an announcement made by Professor C.-E. A. Winslow, of the Yale University School of Medicine, before the recent meeting of the American Society of Heating and Ventilating Engineers.

Although the laboratory is an independent institution, it is conducted in affiliation with the Yale University School of Medicine, with Professor Winslow as director, and its advisory staff is comprised of experts in medicine, physiology, psychology, engineering and physics.

Two years have been spent by the John B. Pierce Foundation in designing and constructing the Laboratory of Hygiene. The object of the foundation, by the terms of the will of the late John B. Pierce, is "the promotion of research, educational, technical or scientific work in the general field of heating, ventilation and sanitation . . . to the end that the general hygiene and comfort of human beings and their habitations may be advanced." Hitherto, facilities for thorough-going research in this field have been lacking.

The central feature of the laboratory is a two-room frame house completely surrounded, above and below and on all four sides, by "shell" spaces. In these six spaces any desired conditions of temperature and humidity can be produced, against which the two experimental rooms can be heated and ventilated by various methods. The test rooms are 15 feet by 12 feet by 9 feet high. Each room has three windows opening on the shell spaces. The rooms are electrically lighted and comfortably furnished with rugs, hangings and household furniture, so that subjects can live in them comfortably for extended periods. There is a control room on the same floor as the test rooms. The first floor of the building, which is on Congress Avenue, opposite the Yale University School of Medicine, contains the entrance lobby and offices and a workshop with lathes and benches for making the necessary equipment. The basement contains the conditioning machinery, constructed especially to meet the requirements of the experiments to be conducted in the laboratory and animal rooms in which atmospheric conditions can be controlled as they are in the test rooms.

Professor Winslow, who is head of the department of public health in the School of Medicine, has as associate directors in the Hygiene Laboratory Dr. Leonard Greenburg and Dr. L. P. Herrington, both of whom hold appointments on the staff of the medical school. The laboratory is now in full operation.

THE EIGHTY-SEVENTH MEETING OF THE AMERICAN CHEMICAL SOCIETY

THE eighty-seventh meeting of the American Chemical Society will be held in St. Petersburg, Fla., from March 25 to 30.

A symposium, the general subject of which will be "The Physical and Chemical Properties of the Isotopes of Hydrogen," will be held on March 27 under the auspices of the Division of Physical and Inorganic Chemistry. Professor Donald H. Andrews, of the Johns Hopkins University, chairman of the division, will preside. Morning and afternoon sessions will be held.

The opening address will be delivered by Professor Harold C. Urey, of Columbia University, who was recently awarded the Willard Gibbs Medal of the Chicago section of the society for his discovery of heavy water. Professor Urey's topic will be "The Isotopes of Hydrogen." Dr. F. G. Brickwedde, of the U. S. Bureau of Standards, associated with Professor Urey in the discovery, will speak on "Vapor Pressure of Deuterium."

Professor Hugh S. Taylor, chairman of the department of chemistry at Princeton University, will discuss "The Hydrogen Isotope as a Research Tool in Chemical Kinetics." In the Frick Chemical Laboratory of Princeton University quantity production of heavy water through a specially constructed machine is under way, and biological experimentation to ascertain the effect of the new liquid upon animals is in progress.

Dr. E. R. Smith, research chemist of the U. S. Bureau of Standards, will present a paper on "The Isotopic Fractionation of Water by Physiological Processes," which he prepared in collaboration with Dr. E. W. Washburn, of the bureau, who died recently. Quantity production of heavy water was achieved by electrolytic methods devised by Dr. Washburn, who was to have been a leading figure in the symposium.

Other speakers and their topics will be: Professor F. Allison, of the Alabama Polytechnic Institute, "The Isotopes of Hydrogen by the Magneto-Optic Method of Analysis"; Professor L. C. Anderson, J. R. Bates and J. O. Halford, all of the University of Michigan,

"Exchange Reactions Involving Deuterium"; D. H. Rank and G. H. Fleming, of the Pennsylvania State College, "Neopentyl Deuteride"; Professor Urey and D. Rittenberg, of Columbia University, "The Thermal Equilibrium Constant of Deuterium Iodide"; Dr. G. H. Dieke, of the Johns Hopkins University, "The Spectroscopy of Deuterium"; Dr. Dieke and R. W. Blue, also of the Johns Hopkins University, "The Analysis of the Spectra HD/D_2."

A symposium on "Indicators" will be held by the Division of Physical and Inorganic Chemistry. Professor C. J. Brockman, of the University of Georgia, will preside. Symposia on naval stores and citrus fruit products are scheduled by the Division of Agricultural and Food Chemistry, of which Donald K. Tressler, of the New York State Agricultural Experiment Station, Geneva, N. Y., is chairman.

Advances in other fields, including medicine and public health, biology, rubber, gas and fuel, sugar, cellulose, colloids, and water, sewage and sanitation, will be described in several hundred papers and addresses.

The Gas and Fuel Division will meet under the chairmanship of Dr. Harold J. Rose, of the Mellon Institute, Pittsburgh. Among the speakers are D. A. Reynolds, Bureau of Mines Experiment Station, Pittsburgh; Dr. Gustav Egloff and Dr. J. C. Morrell, Universal Oil Products Company, Chicago.

Other divisions which will hold sessions, and their chairmen, are: Division of Biological Chemistry, Professor Robert C. Lewis, of the School of Medicine, University of Colorado; Division of Cellulose Chemistry, Carleton E. Curran, director of pulp and paper research, Forest Products Laboratory, Madison, Wis.; Division of Chemical Education, Professor Ross A. Baker, College of the City of New York; Division of Colloid Chemistry, Professor Wesley G. France, of the Ohio State University; Division of Industrial and Engineering Chemistry, Walter G. Whitman, Standard Oil Company of Indiana, Whiting; Division of Medicinal Chemistry, Dr. Paul Nicholas Leech, American Medical Association, Chicago; Division of Organic Chemistry, Dr. C. S. Hudson, Hygienic Laboratory, Washington; Division of Paint and Varnish Chemistry, R. J. Moore, Bakelite Corporation, Bloomfield, N. J.; Division of Rubber Chemistry, Ira Williams, Woodstown, N. J.; Division of Sugar Chemistry, Otto A. Sjostrom, Corn Products Refining Company, Argo, Ill.; Division of Water, Sewage, and Sanitation Chemistry, Edward S. Hopkins, Bureau of Water Supply, Baltimore.

The Council and Board of Directors will convene on the opening day when reports of officers and committees will be received and plans for the development of the professional activities of the society will be considered. Officers of the local sections, assembled from all parts of the country, will also meet. The leading industries of Florida will be inspected.

An elaborate program of entertainment has been arranged by a local committee, with the cooperation of the city government and of industrial, civic, patriotic, professional and social organizations. The chairman of the committee is Dean Townes Randolph Leigh, of the College of Arts and Sciences of the University of Florida.

RECENT DEATHS

MRS. ELIZABETH GERTRUDE BRITTON (Mrs. Nathaniel Lord Britton), honorary associate instructor and curator of the moss collection of the New York Botanical Garden, died on February 25, at the age of seventy-six years.

WILLIAM BEUTENMÜLLER, for twenty years curator of the department of entomology at the American Museum of Natural History, died on February 24 in his seventieth year.

DR. FELIX NEUMANN, until recently assistant librarian at the Army Medical Library, died on February 7. He was seventy-six years old.

IRA A. WILLIAMS, consulting geologist of Portland, Oregon, died at his home on January 22. He was fifty-eight years old.

THE death is announced of Dr. Julius Bauschinger, professor of astronomy at the University of Leipzig.

THE Academy of Science of St. Louis has passed the following resolution in honor of Otto Widmann, one of its two honorary members, who died on November 26 in his ninety-third year.

WHEREAS, Otto Widmann has given his life to science, has enriched the field of ornithology by original contribution, especially by the increase of knowledge of the avifauna of Missouri; and,

WHEREAS, He has been a supporter, staunch and faithful, of the purposes and endeavors of the St. Louis Academy, strengthening it by his interest and activity; and,

WHEREAS, Otto Widmann's example of enduring devotion to science has been an inspiration to his colleagues and to the younger generation of ornithology; therefore, be it

Resolved, That the Academy of Science of St. Louis record with deep regret the passing of a loyal member, a distinguished investigator, a gentle and lovable personality.

SCIENTIFIC NOTES AND NEWS

HOWARD NICHOLAS EAVENSON, consulting engineer, was elected president of the American Institute of Mining and Metallurgical Engineers at the annual meeting recently held in New York City.

THE Lamme Medal of the American Institute of Electrical Engineers for 1933 has been awarded to Dr. Lewis B. Stillwell, consulting engineer of New York City, "for his distingiushed career in connection with the design, installation and operation of electrical machinery and equipment." The medal will be presented at the summer convention of the institute, which is to be held at Hot Springs, Virginia, June 25 to 29. Previous recipients of the awards of the Lamme Medal of the institute were: Allen B. Field, 1928; Rudolf E. Hellmund, 1929; William J. Foster, 1930; Giuseppe Faccioli, 1931, and Edward Weston, 1932.

THE Faraday Medal of the British Institution of Electrical Engineers has been awarded to Sir Frank E. Smith, secretary of the Department of Scientific and Industrial Research. The medal is awarded "for notable scientific or industrial achievement in electrical engineering or for conspicuous service rendered to the advancement of electrical science, without restriction as regards nationality, country of residence, or membership of the institution."

MEMBERS of the staff of the School of Medicine of Western Reserve University, Cleveland, gave a luncheon in honor of the sixtieth birthday of Dr. Torald Sollmann, dean of the school, on February 10. Those present included Dean W. G. Leutner, acting president; Dr. Charles F. Thwing, president emeritus; Dr. Robert H. Bishop, director of University Hospitals, and Dr. George W. Crile, professor emeritus of surgery. In memory of the occasion, Dr. Sollmann was given a decorated parchment manuscript in a blue pinseal folder, hand tooled in gold, inscribed as follows: "To Torald Hermann Sollmann: Your colleagues have gathered together to felicitate you upon the occasion of your sixtieth birthday, to congratulate you upon the scientific achievements which have given you eminence the world over. Your academic career, begun and continued in Western Reserve University, has brought luster to your name and distinction to the institution, which through many channels, you have served selflessly, faithfully, enthusiastically, energetically, and with inspiring loyalty. With affection, admiration and respect, we wish you many more years of fruitful investigation and happiness."

ON February 17, about 400 members of the Bureau of Plant Industry, together with representatives of various other bureaus of the Department of Agriculture, gathered in the main building of the department to do honor to Dr. W. A. Taylor, who recently retired as chief of the Bureau of Plant Industry. In the course of the afternoon, Mr. H. P. Gould, who was for a long time associated with Dr. Taylor in horticultural investigations, presented him with a leather-bound souvenir volume which contained the following expression of appreciation signed by those present and by a considerable number of field employees of the Bureau of Plant Industry. "William A. Taylor, chief of the Bureau of Plant Industry from 1913 to 1933, and for more than forty-two years active in the work of the United States Department of Agriculture, life-long student of horticultural science, pioneer in broadening the field of botanical research, untiring leader, sympathetic adviser, keen and kindly critic of manuscripts, promoter of friendly cooperation, exemplar of the square deal in administration; this personal testimonial of grateful appreciation is affectionately dedicated by the members of the bureau he has so ably served."

DR. W. J. TURRELL, physician-in-charge of the electrotherapeutic department of the Radcliffe Infirmary, Oxford, has received from Dr. Norman E. Titus, of New York, the Gold Key awarded to him at the last annual meeting of the American Congress of Physical Therapy. The distinction is the highest awarded in the United States for original research and distinguished services in the field of electrotherapy. The presentation was made to Dr. Turrell at a dinner given to Dr. Norman Titus by Dr. Howard Humphris, to whom the award was made by the congress in 1932.

ON the occasion of the centennial of the Medical School of the Ohio State University, which will be held on March 1, 2 and 3, the degree of doctor of science will be conferred on Dr. Henry S. Houghton, associate dean of the biological sciences at the University of Chicago; on Dr. Torald H. Sollmann, professor of pharmacology and materia medica at the School of Medicine of Western Reserve University, and on Dr. William S. McCann, Dewey professor and director of the department of medicine in the School of Medicine and Dentistry in the University of Rochester and physician-in-chief of the Strong Memorial Hospital.

DR. JOSEPH S. AMES, president of the Johns Hopkins University, on February 22 attended for the fiftieth time the commemoration day exercises. Dr. Ames entered the university as an undergraduate student in 1883 and has been associated with the university ever since with the exception of a year spent at the University of Berlin in 1886–87.

IN connection with the fiftieth anniversary of Tem-

ple University the doctorate of science was conferred on February 16 on United States Senator Royal S. Copeland, of New York; on Dr. George E. de Schweinitz, of the University of Pennsylvania, and on Dr. Albert L. Midgley, Providence, Rhode Island, secretary of the Dental Educational Council of America.

THE first award of the George W. Carpenter Fund for encouragement of scientific research has been made by the Academy of Natural Sciences of Philadelphia to Dr. Francis W. Pennell, curator of botany for his work on the Snapdragon family of eastern North America. In presenting the $250 honorarium at the annual meeting, Effingham B. Morris, president of the academy, announced that this fund also would permit publication of Dr. Pennell's book on the subject. The George W. Carpenter Fund is a bequest from the late Mrs. Ellen D. C. Bennett, in memory of her father, one of the earliest members of the academy, who served as treasurer of the institution from 1826 to his death in 1880.

THE American Association of University Women has announced that its Sarah Berliner Research Fellowship of $1,200 has been awarded to Dr. Emma Dietz, Brooklyn, now engaged in chemical research at Harvard University.

PROFESSOR EDWARD ELLERY, professor of chemistry at Union College and dean of the faculty, who, since the retirement last April of President Frank Parker Day, has been serving as acting president of the college, will return to his work in the department of chemistry at the close of the academic year. Dr. Dixon Ryan Fox, professor of history at Columbia University and president of the New York State Historical Association, has been elected to succeed Dr. Day as president.

DR. DAVID D. WHITNEY, professor of zoology, has been appointed chairman of the department of zoology at the University of Nebraska. He succeeds Dr. Robert H. Wolcott, who died on January 23.

DR. FREDERICK A. DAVIDSON, associate aquatic biologist of the Bureau of Fisheries, has been appointed acting director of the Fisheries Biological Laboratory at Seattle, Washington, relieving Joseph A. Craig, who has been serving as director since 1931.

DR. LESLIE C. DUNN, professor of zoology at Columbia University, has been given leave of absence for the academic year 1934–35; Dr. Charles C. Leib, Hosack professor of pharmacology, and Dr. Joseph F. Ritt, professor of mathematics, have leave of absence for the winter session. Leave of absence for the spring session has been granted to Dr. Gary N. Calkins, professor of protozoology; Dr. Earl Theron Engle, associate professor of anatomy; Dr. Harry L. Hollingworth, professor of psychology; Arthur F. Taggart, professor of mineral dressing; Dr. Dudley J. Morton, associate professor of orthopedic surgery, and Dr. Edmund W. Sinnott, professor of botany.

ACTING at the request of the Forest Conservation Conference, Secretary Ickes has appointed to the executive committee as representative of public interest: Earle H. Clapp, assistant forester in charge of research, U. S. Forest Service; Ward Shepard, Indian Service; W. G. Howard, state forester, New York; O. M. Butler, executive secretary, American Forestry Association, and B. P. Kirkland, U. S. Forest Service.

DR. HARRY S. SMITH, entomologist at the Citrus Experiment Station of the University of California at Riverside, has been appointed chairman of the Standing Committee on Pacific Entomology, a branch of the Pacific Science Congress. The committee has been named to promote cooperation in the solution of entomological problems existing in nations bordering on the Pacific Ocean, particularly in relation to preventing the spread of pests from one country to another, and the interchange of beneficial insects for the control of pests.

THE Committee on Scientific Research of the American Medical Association has made the following grants-in-aid: Phillips Thygeson, University of Iowa, for work on virus diseases of the eye; Harry Goldblatt, Western Reserve University, for a study of experimental hypertension in dogs; Paul Visscher, Western Reserve University, for work on a chemical test for pregnancy; M. D. Overholser, University of Missouri, for work on experimental production of new growths in the genital tract of the monkey and on the relation of anterior hypophysis to experimental diabetes; M. G. Seelig, Barnard Free Skin and Cancer Hospital, St. Louis, for a study of radiosensitivity of neoplasms; C. Alexander Hellwig, St. Francis Hospital, Wichita, Kansas, for study of the thyroid function in colloid goiter; L. A. Emge, Stanford University School of Medicine, for work on the relation between pregnancy and tumor growth; Charles J. Sutro, Hospital for Joint Diseases, New York, for investigation with fluorescent microscope; M. L. Tainter, Stanford University School of Medicine, for study of the metabolic action of dinitrophenyl in man; Bernard Portis, Michael Reese Hospital, Chicago, for study of the immune reactions of the Flexner-Jobling rat tumor.

THE "Mangareva Expedition" has been organized by the B. P. Bishop Museum for conducting studies of ethnology and natural history in the little-known parts of southeastern Polynesia. Because other means of transportation are unavailable, the expedi-

tion is provided with two ships. The *Islander* (Captain W. G. Anderson), a high-powered sampan, will leave Honolulu on March 1 and during a six months' cruise will serve as a "master ship" for investigators, chiefly at Mangareva, Oeno, Pitcairn, Rapa, Tubuai, Rurutu, Raivavae and Rimitara islands. The second ship, the cutter yacht *Tiare Tahiti* (Captain Robert S. Burrell), under charter from May to October, will serve primarily as a "transfer ship" for the ethnologists at work in Mangareva and among the 360 islands of the Tuamotu Archipelago. The chief purpose of the expedition is to record data regarding native races, flora and land fauna, which are disappearing at a surprisingly rapid rate. Incidental observations on geology, marine zoology and general oceanography will also be made. The scientific staff includes Dr. Peter H. Buck, Kenneth P. Emory and J. Frank Stimson, ethnologists; Professor Harold St. John and Raymond Fosberg, botanists; Dr. C. Montague Cooke, Jr., and Donald Anderson, malacologists, and E. C. Zimmerman, field entomologist. Dr. C. Montague Cooke, Jr., has been appointed leader of the expedition.

DR. ROBERT A. MILLIKAN, of the California Institute of Technology, on November 1 delivered before the University of California at Los Angeles Chapter of the Society of the Sigma Xi an illustrated lecture on his recent work.

DR. EDWIN GRANT CONKLIN, professor of zoology at Princeton University, gave on February 20 one of a series of lectures arranged for the undergraduates of the New Jersey College for Women.

DR. LAFAYETTE B. MENDEL, Sterling professor of physiological chemistry at Yale University, addressed the Philadelphia Home Economics Association on February 15. His subject was "Nutrition and the Chemist."

DR. ALBERT W. HULL, assistant director of the research laboratory of the General Electric Company, Schenectady, New York, gave a lecture before the Franklin Institute on February 21 on "Fundamental Phenomena in Thyratrons."

DR. FRANK CHARLES MANN, professor of experimental surgery at the Mayo Foundation, will deliver the Stuart McGuire Lectures for the current year on the nights of April 2 and 3 at the Medical College of Virginia, Richmond. He will speak on "The Anatomy and Physiology of the Liver" and "Experimental Pathology of the Liver." The Stuart McGuire lectureship, inaugurated during the session 1929–30 in recognition of Dr. McGuire's service as teacher and president of the Medical College of Virginia, has been filled thus far by Dr. William J. Mayo, Rochester, Minnesota; Dr. S. A. Mitchell, University of Virginia; Dr. James S. McLester, University of Alabama Medical School, and Dr. Ronald T. Grant, University College Hospital Medical School, London.

RECENT lectures and clinics at Duke University were given as follows: Dr. George L. Streeter, of the Carnegie Institution Department of Embryology, Baltimore, on "Foetal Amputations"; Dr. E. F. Lowry, of the U. S. Navy Recruiting Station, at Raleigh, N. C., on "A Medical Career in the Navy." Dr. Charles D. Lucas and Dr. Fred W. Stewart, of the Memorial Hospital for the Treatment of Cancer and Allied Diseases, New York City, gave a clinic on "Cancer."

THE February lecture on the Smith-Reed-Russell series at the School of Medicine of George Washington University was delivered by Dr. Edward Francis, of the National Institute of Health, who spoke on "The Study and Control of Tularemia." Dr. Elliott Proctor Joslin, clinical professor of medicine in the Harvard Medical School, addressed the students in the School of Medicine on February 12 on "Diabetes."

SIR ARTHUR EDDINGTON gave the Rickman Godlee Lecture at University College, London, on February 16 on "The Constitution of the Stars." The chair was taken by Lord Dawson of Penn.

DR. G. ELLIOT SMITH, professor of anatomy in the University of London, recently delivered three lectures at the Royal Institution on "Human Biology."

THE trustees of the New York Museum of Science and Industry have installed an exhibition illustrating that "Science and Invention Make More Jobs." A preview was held on February 22 at which Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, and Dr. Robert A. Millikan, of the California Institute of Technology, were especially invited guests. At a meeting in the evening arranged by the New York Electrical Society and the American Institute of Physics, addresses were made on the subject by Drs. Compton and Millikan and by Dr. F. B. Jewett, president of the Bell Telephone Laboratories.

THE American Society of Mammalogists will hold its sixteenth annual meeting at The American Museum of Natural History, New York, from May 8 to 12. Concurrently the American Society of Ichthyologists and Herpetologists and the American Association of Physical Anthropologists will meet in New York.

THE Fifth Annual Greater New York Safety Conference will be held at the Hotel Pennsylvania, New York City, on March 6 and 7.

A JOINT meeting of the Wisconsin Academy of Sciences, Arts and Letters, the Wisconsin Archeological Society and the Midwest Museums Conference will be held at Lawrence College, Appleton, Wisconsin, on April 6 and 7. Two concurrent sections will

be held for the reading of papers: Section A for archeology, history, literature and the social sciences; Section B for zoology, botany, physics, chemistry, astronomy, mathematics and applied science. The annual academy dinner will be held on Friday evening, April 6. Following the dinner Professor Laurence M. Gould, of Carleton College, will give an illustrated lecture on some phase of his experiences and observations as geologist with Commander Byrd's first South Polar Expedition.

PRESIDENT ROOSEVELT has transferred the Bureau of Mines from the Department of Commerce to the Department of the Interior where it was prior to the Hoover administration. The transfer will become effective in sixty days unless vetoed by the Congress.

BY an agreement between the War and Interior Departments the whole of Bedloe's Island will be made a national monument and will be transferred to the Office of National Parks, Buildings and Reservations.

THE Museum of the American Indian, Heye Foundation, will erect on a six-acre plot owned by the museum in the Bronx, New York City, full-sized reproductions of American Indian dwellings and ceremonial buildings.

DRS. WILLIAM J. AND CHARLES H. MAYO, of the Mayo Foundation, Rochester, Minnesota, have given $500,000 to the University of Minnesota to supplement the endowment of $1,500,000 provided by them originally for the foundation. The Mayo Clinic opened in 1915 when the original fund had grown through interest to $2,000,000.

DR. ANNIE J. CANNON, curator at the Harvard Observatory, who last year received the prize of $1,000 awarded by the Association to Aid Scientific Work by Women, has contributed the amount of the prize to found the Annie J. Cannon Prize, to be awarded every three years for a distinguished contribution to astronomy by a woman. The fund will be administered by the American Astronomical Society, and the first award will be made in December.

THE London *Times* writes: The practise which is being increasingly adopted in industry and commerce of setting scientifically devised intelligence and psychological tests to applicants for employment has now been put into use by Messrs. Peek, Frean and Company, Limited, who employ some 4,000 people at their works in Bermondsey in the production there of over 40,000,000 biscuits a week. During the last few days a number of juvenile applicants for posts have been interviewed and tested., Mr. J. H. Fullwood, employment manager at the works and president of the Institute of Labor Management, stated recently that investigations showed that the labor turnover at the works was too high and uneconomic. The National Institute of Industrial Psychology were approached, and certain specially designed tests were supplied. The firm had now adopted a four-years' plan for the scientific selection of juvenile workers, and already the results indicated that the tests were sound, and he was hopeful that they would bring about a substantial reduction of the wastage of labor turnover.

DISCUSSION

A SUGGESTION REGARDING THE CHEMICAL FORMULAE OF COMPOUNDS CONTAINING HYDROGEN AND OXYGEN ISOTOPES

PRIOR to the discovery of the isotope of hydrogen of mass 2, the isotopes of chemical elements did not introduce difficulties in the writing of chemical formulae, because it had been found impossible (with any technique known at the present time) to separate into its component atoms an isotopic mixture. With the discovery of hydrogen of mass 2, however, we are faced with not only the possibility of a complete separation of the hydrogen isotopes from each other but also with the fact that in all probability we are upon the threshold of a new series of organic compounds in which hydrogen of mass 2 may be substituted either wholly or in part for hydrogen of mass 1. It therefore appears imperative that some uniform scheme be devised to designate the structural formulae of such organic compounds.

Various suggestions have already been put forth. It has been suggested that hydrogen of mass 2 be called "deuterium," with hydrogen of mass 1 to be known as "protium." It has been further suggested that a hydrogen of mass 3 may exist and that this could be called "tritium." Some workers have suggested that the symbols for these isotopes of hydrogen might be "D" for deuterium and "Pm" for protium. No one has as yet suggested a symbol for tritium, although apparently by analogy this would be "Tr."

The writer objects strongly to the use of such symbols, believing that they would greatly confuse the beginning student and would greatly slow up the thinking processes of even the expert. An alternative suggestion which has already been used rather extensively is to employ both subscripts and superscripts, the superscript indicating the mass of the isotope, the subscript having its usual meaning in chemical symbols; thus H^2_2O would indicate water containing only

the hydrogen isotope of mass 2, HH^2O would indicate water one half of the hydrogen of which contained the isotope of mass 2, the other half having mass 1, and H_2O standing for water containing only the isotope of mass 1. While these designations appear to be satisfactory for simple compounds, the use of superscripts introduces difficulties when the formulae of complex organic molecules are involved, particularly so if one desires to write graphic formulae. There is also an appreciable increase in printing cost to be considered.

I would like to suggest a further alternative. Hydrogen of mass 2 is already extensively referred to as "heavy hydrogen." This could be designated in typesetting by a bold-faced letter "**H**." Thus, we can have $\mathbf{H}_2O$, **H**HO, and H_2O, indicating, respectively, water containing only heavy hydrogen, water containing one-half heavy hydrogen and water containing no heavy hydrogen. Similarly, we can write organic formulae in exactly the same way that we write them at the present time, excepting that all the hydrogens or particular hydrogens are printed, using the bold-faced type to indicate that these hydrogens have mass 2.

If hydrogen of mass 3 is ever produced in sufficient quantities to be used in preparing chemical compounds of known structure, its presence can be indicated by a bold-faced Old English letter "H."

Similarly, oxygen of mass 18 can be indicated by a bold-faced letter "O" and oxygen of mass 17 (which appears to be the rarer of the oxygen isotopes) can be indicated by a bold-faced Old English letter "O."

Such designation of the hydrogen and oxygen isotopes will make possible the use of graphic formulae of organic compounds which differ in no way from the present formulae, excepting that particular hydrogens or oxygens will be designated as for a special mass, differing from the mass of other hydrogens or oxygens which may be united to form similar compounds, but compounds which have different physical (and perhaps chemical) properties. Thus, for example, we may have mono-**H**-benzene, *o.* (or *m.* or *p.*) di-**H**-benzene, 1.2.3. (or sym.) tri-**H**-benzene, etc., for all the known organic compounds, without introducing any ambiguity into the nomenclature.

ROSS AIKEN GORTNER
UNIVERSITY OF MINNESOTA

PARA-ORTHO CONVERSION OF DEUTERIUM[1]

USING thermo conductivity method we have succeeded in showing the para-ortho conversion of deuterium at 78°, 53°, 20.4° Kelvin changes in readings relative to normal deuterium being in ratio 3 to 11 to 30, respectively. This agrees with the Bose-Einstein statistics if the nuclear spin of the deutron [deuton?] is the one which gives excess concentration of 3.3, 11.1 and 31.2 per cent., respectively, of orthodeuterium at these temperatures relative to normal deuterium. Velocity constant of reconversion of orthodeuterium by oxygen at room temperature is sixteen times smaller than that of parahydrogen, being 0.57 liters per mol, per min.

ADALBERT FARKAS
LADISLAUS FARKAS
PAUL HARTECK

COLLOID SCIENCE LABORATORY,
UNIVERSITY OF CAMBRIDGE

[1] Received by cable.

GOVERNMENT RESEARCH

IN a recent number of SCIENCE (January 26) attention was called to the reduced appropriations to the U. S. Department of Agriculture, which have necessitated drastic cuts in experiment and scientific research, including the dismissal of 567 workers in scientific projects. It is rather difficult to understand the necessity for so much retrenchment in established activities when the government is at the same time spending vast sums (stated to be over $200 per second) on its national recovery program. An explanation attributed to Assistant Secretary Tugwell is given in an editorial review in the current number of *The Reader's Digest*. This statement repeats the basic idea of the New Deal, that the purchasing power of the farmers and factory workers must be restored, for which at least 5 billions of dollars was needed. It then adds: "Meantime ordinary government expense had to go on *and this expense had to be kept down and carefully watched.* To take care of the extraordinary expense there had to be also an extraordinary budget. . . . A business man may borrow large sums to modernize his plant or find new markets."

Probably no one will deny the advisability of a business man borrowing, under certain conditions, to modernize his plant or to find new markets, but his wisdom might well be questioned if, in making these improvements, he allowed his existing efficient machinery to deteriorate so that it would have to be replaced, resulting not only in additional cost but also in delay in getting into effective production on the new scale. Similarly, even though we may be in sympathy with the government's recovery program and appreciate the need of efficiency and economy in ordinary government operations, nevertheless we may question whether wisdom is being shown in drastic budget reductions which mean actual elimination of many lines of investigation and consequent interruption of fact-finding activities vital to the efficient administration of many government functions.

By way of illustration I should like to cite some of the work of the Bureau of Biological Survey. Let it be granted that all possible economies should be made and it is also possible that some reorganization or shift of emphasis may be desirable in the Biological Survey as elsewhere; but such economics and reorganization should be undertaken intelligently, with due regard to the importance and balance of the activities concerned. Unfortunately the evidence, as indicated in the reductions of last year and the present proposed budget, gives little indication of such a study of the situation having been made. In the case of the Biological Survey, for example, the policy appears to have been to continue the regulatory functions and to cut out completely the fact-finding activities on which all sound regulation policies must be based. This action would appear to have been inspired by the recently promulgated fallacy that science has already produced more results than the economic system has been able to absorb and therefore science should take a vacation and allow the social order to catch up.

In the budget now before Congress the appropriations for investigations on migratory birds, the food habits of birds, and diseases and other problems of fur-bearing animals, are not merely reduced, they are completely eliminated. Let us take the case of the migration studies as an example and see what the consequences would be. The Migratory Bird Act and the broad problems of bird refuges, the use of submarginal lands and the like, depend for their intelligent administration on knowledge of the abundance, distribution, migrations and other habits of birds. For many years the Biological Survey has been accumulating information on these points, but no matter how complete such information may be at one time it will not answer future needs any more than economic remedies of to-day can be based on the census of 1900. But even more important, by means of cooperative banding of birds on a large scale, the survey has in recent years built up an agency for gaining definite information on the movements and life histories of birds which is producing results of the greatest scientific and practical value. Approximately 1,900 persons, scattered all over the country, are cooperating voluntarily in this work. Since 1920 at least one and a half million birds have been banded and "returns" have been obtained on at least 90,000 of them. If the voluntary work that has gone into the obtaining of these invaluable records had to be paid for it would certainly run up into the hundreds of thousands of dollars. It should be pointed out that the large function of the Biological Survey in this work is to act as a repository and clearing house for the records that are accumulated through the efforts of these hundreds of voluntary collaborators. If the directive and coordinating work of the survey should stop, not only would it result in a complete paralysis of the banding operations, but records of inestimable value on birds already banded would be lost, and a smoothly functioning machinery would be destroyed which would require years to replace. Furthermore, the present highly skilled direction and supervision would be dissipated and could not be reassembled without much delay in time and effort, if at all.

The success of bird-banding as a method of gaining definite information has stimulated many special studies by individuals, by colleges and by state conservation bodies. The Biological Survey has cooperated by supplying bands and acting as a central repository for all records of recovery. Termination of this service would place a great handicap on such studies since, if each were to issue its own series of bands, inefficiency and hopeless confusion would result. To continue this particular activity of the survey on at least a functional basis would require $12,000 to $15,000 annually, while $20,000 to $25,000 would enable it to do its work effectively and well. It may be necessary in these times to reduce the work to a minimum effective operating level; but if the New Deal produces the results that are hoped for it, it is surely consistent with sensible economy to see that essential parts of the government's research program are not allowed to disintegrate.

What has been said with regard to the bird-banding work would apply with equal force to other fundamental research and "clearing-house" activities, not only in the Biological Survey but in the Department of Agriculture as a whole and in other government branches. If, in the zeal to speed recovery, research activities fundamental to government administration and regulation are in danger of neglect, to the point where they are seriously crippled or completely disorganized, it is a matter of grave concern not only to persons interested in the welfare of science, but to the general public as well. It is greatly to be hoped that some system of government budget-making may be devised whereby the needs of different activities may be evaluated and coordinated on a basis of logic and reason, rather than to be left largely to the whims of chance or to pressure exerted by specially interested or political groups.

L. J. COLE

UNIVERSITY OF WISCONSIN

THE LAW OF MULTIPLE PROPORTIONS

IN the January 5, 1934, issue of SCIENCE, Professor E. A. Vuilleumier points out that the law of multiple proportions (as ordinarily stated in text-books) does not hold true, even for some standard text-book prob-

lems. He suggests the addition of a codicil so that the law reads "the ratio of small whole numbers or their reciprocals." This addition is not necessary, but it is necessary to omit the word "small" from the ordinary statement of the law so that it reads "the ratio of whole numbers."

This statement of the law takes care of the oxides of nitrogen problem discussed by Professor Vuilleumier. For a fixed weight of oxygen the weights of nitrogen in the several oxides are exactly in the ratio of 60 : 30 : 20 : 15 : 12. The same statement also provides for cases such as palmitic, stearic and oleic acids, where the weights of hydrogen for a fixed weight of oxygen are in the proportion of 16 : 18 : 17. Organic chemistry supplies many such cases.

ARTHUR ROSE

THE PENNSYLVANIA STATE COLLEGE

THE UNITED STATES BOTANICAL GARDEN

GEORGE HESS, director of the United States Botanical Gardens is retiring (as emeritus?). This is a time when all scientists, botanists in particular, should address their senators asking that the director of the U. S. Botanical Gardens should be a scientist, a botanist, who will make the gardens a Botanical Garden in fact. At present it exists purely for the propagation of plants for friends of congressmen, and for providing decorations for congressional functions.

A scientist could cater to such needs and yet develop a real botanical garden in the national capital. Years ago Dr. Liberty Hyde Bailey asked that either Congress develop a Botanical Garden of that project, or change the name. Nothing was done; it continues to "fill orders from congressmen" without a botanical background.

This administration seems to be doing things differently—maybe they will follow Bailey's suggestion if it is called to their attention by their scientific constituents.

The gardens are under the direction of the Library of Congress Committee, consisting of A. W. Barkeley, of Kentucky; K. McKeller, of Tennessee; E. Thomas, of Oklahoma; Hattie Caraway, of Arkansas; P. Norbeck, of South Dakota; S. Fess, of Ohio; W. W. Barbour, of New Jersey, and E. Gibson, of Vermont. Letters should be sent to the Senator of your own state.

F. A. VARRELMAN

AMERICAN UNIVERSITY,
WASHINGTON, D. C.

REPORTS

MEMORANDUM ON THE ALL-UNION INSTITUTE OF EXPERIMENTAL MEDICINE[1]

PRELIMINARY conferences on the plans of the All-Union Institute of Experimental Medicine have dealt entirely with technical matters on construction, arrangement and equipment. It seems desirable to conclude these conferences with a general statement.

I preface my remarks by calling attention to my own limitations, which are those of one who for many years has taken no personal part in laboratory research, but whose attention has been confined to the planning and administration of medical institutions and to public health work.

Of the general aims of the institute, I can speak only with admiration and approval. No individual, no foundation and no government has hitherto entered the field of experimental medicine with a scheme of equal proportions. The history of scientific medicine is a record of the efforts of mankind to elicit and to explain the facts of life, and to protect itself from danger, discomfort and death. In modern times both hereditary and environmental influences have been intensively studied. In the larger and more advanced states, prior to the world-wide depression, capital was poured into the construction and equipment of institutions dedicated to the study and prevention of disease. The volume of this work in the United States has been enormous. It has been carried on in many laboratories scattered over the entire country. The greatest of these establishments has a comparatively meager program in comparison with the ambitious, comprehensive program of the All-Union Institute of Experimental Medicine, which aims at the eventual command of all the natural and social forces which affect human life.

In the United States, coordinated medical research programs are found chiefly in a few famous institutes and in so-called medical centers, consisting of groups of hospitals whose main object is the treatment of the sick; in these centers, scientific investigation is very largely a by-product, albeit an important one. But, as I have already intimated, no single institution possesses anything like the resources with which it is proposed to equip and endow the institute in Leningrad.

The basic principle of the Leningrad institute might be said to be that of comprehensive, coordinated, biological study. The outlook of isolated laboratory workers, especially those whose attention is concentrated on highly specialized studies, often

[1] Statement prepared at the suggestion of delegates of the U. S. S. R., at the close of a conference in New York City to consider plans for an All-Union Institute of Experimental Medicine at Leningrad.

suffers from want of contact with critical minds engaged in related pursuits. The assemblage in one institution of hundreds of disciplined thinkers and skilled workers promises rich rewards springing from a variety of stimulating associations. Such associations are mentally challenging and corrective. Apart from the theoretical benefits of association, the institute will offer the practical advantages of group investigations, by means of which different angles of the same problem can be simultaneously and stereoscopically illuminated.

Nobody can foretell just what the outcome of the work of the institute will be in volume or in kind. The members of a large laboratory staff are never uniformly talented or resourceful. In any large group of men engaged in a common effort, leadership growing out of the superabundance of vitality or the superior imagination of individuals will inevitably assert itself. It will be particularly fortunate for biological science, if those members of the institute who possess superior native endowment happen to be men or women whose attention is fixed upon problems appropriate to the present and future rather than on scientific problems of waning interest. As biological concepts change, there occurs a corresponding alteration in the value of the different branches of research. Laboratories, once brilliant, have been known to lose their productiveness by adhering too long to types of investigation which, although originally of great significance, have ceased to be important.

Sometimes the peculiar outlook of divisional chiefs has an unlooked-for and desirable effect upon laboratory developments. I have no doubt that at the institute at Leningrad, precautions will be taken to prevent the blighting influence of a too rigid control of the younger workers by leaders, however eminent, whose interests are fixed upon untimely or passing phases of science. I could point to scientific centers in other countries, where there has grown up among those occupying ranking positions an unfortunate sense of self-satisfaction, an inclination to continue in well-worn grooves and a disposition to look with suspicion upon resourceful and original thinkers and workers, who, for personal, social or political reasons, have not commended themselves to those in charge as congenial coworkers. Where the choice of workers is thus influenced, the effectiveness of a laboratory may be seriously impaired. Bureaucratic dangers are encountered in every large organization, and it requires the utmost vigilance to avert them. These observations are made, of course, in a general sense, and must not be interpreted as in any way reflecting on the actual personnel of the institute—a personnel which includes men of great eminence, and one which, from all accounts, is fully qualified to deal with the problems which confront it.

In order to prevent scientific organizations from congealing, such organizations in the United States, England and elsewhere have adopted protective measures such as an age limit or service limit. If too rigidly applied, rules of this kind, which are intended to give youth its fling, may do harm, but if applied leniently where leniency is obviously indicated by the circumstances, they may accomplish a great deal of good. In science more than in any other field, good men whose imaginations are continuing to function must not be cut off in their prime.

I note with interest and with warm approval that in the plan under consideration provision has been made for the assignment of laboratory facilities to visiting scientists from foreign countries. Notwithstanding the great scope of the institute's plan, it is likely that from time to time ideas will spring up outside of Russia, which can be profitably brought into the institute and exploited there, hence the proposal to associate foreign scientists with the regular staff of the institute is extremely prudent. No doubt additional foreign contacts will be sought by sending members of the institute abroad from time to time.

To survey the entire field of biological science and to bring together in one master organization workers in all the related sciences is an entirely logical plan, a plan of which any country might well be proud, and one which is peculiarly appropriate to a socialized state. The actual project is one of such stupendous scope that it staggers the imagination. And yet I have no doubt that it will be viewed with some skepticism by a not inconsiderable group of thinkers who believe that the greatest scientific advances are made, not as the result of large-scale systematically planned research but because of the genius of talented individuals, who, in spite of obstacles of whatever kind, create their own opportunities by sheer personal force. Philosophers of this school of thought will expect to find arid areas in the spreading laboratories of the institute. In the long run, the value of the institute can be justly measured only by the aggregate of its positive accomplishments; if these are great, a few personal failures can be tolerated.

In so large a project as the one under contemplation, it will be difficult to find men of precisely the right quality to fit into every niche in the organization. The institute will need men who can work in both single and double harness. It is fascinating to contemplate a laboratory or group of laboratories which, theoretically at least, will afford a suitable opportunity for every young scientist in Russia who has a real contribution to make. No one knows what science and humanity have lost through the failure of the civilized countries of the world to provide adequate opportunities for all their budding geniuses. Lack of means has crippled opportunity here, and

prejudice or want of sympathetic understanding there. The institute at Leningrad will need plenty of means, which the government is presumably prepared to supply, and an open mind toward all who can serve its purpose.

I do not exaggerate when I say that scientists in the United States look with admiration and with a certain amount of envy upon the All-Union Institute of Experimental Medicine and its magnificent program, and with respect upon a government that is ready to give its support in so liberal a measure to the search for truth and the promotion of human well-being.

S. S. GOLDWATER

DEPARTMENT OF HOSPITALS
NEW YORK, N. Y.

SOCIETIES AND MEETINGS

THE WESTERN SOCIETY OF NATURALISTS

THE sixth annual winter meeting of the Western Society of Naturalists was held at Asilomar, Pacific Grove, Calif., on December 27, 28 and 29, 1933, with Dr. S. C. Brooks presiding. The meetings included three symposia on subjects of special interest and two evening meetings as well as a series of submitted papers.

The first symposium, arranged by Dr. C. V. Taylor, was entitled "Internal Environments in Amphibian Morphogenesis." It included the following papers: "Rôle of the Organizer in the Axial Development of Amphibia," by J. Frank Daniel, of the University of California; "Non-glandular Regulation of Relative Growth in Amphibia," by V. C. Twitty, of Stanford University; "Hormone Action in Amphibian Development," by B. M. Allen, of the University of California at Los Angeles; and "Temperature Gradients in Amphibian Development," by F. G. Gilchrist, of Pomona.

"Environmental Effects on Plants" was the title of the second symposium. It included the following papers: "Environmental Transformation of Bacteria," by W. H. Manwaring, of Stanford University; "Cytogenetic Effects of High Frequency Radiations on Plants," by T. H. Goodspeed, of the University of California; "On the Environmental Modifiability of Certain Plant Forms," by W. M. Heusi, of the Carnegie Institution of Washington; "Distribution of Newfoundland Desmids," by Wm. R. Taylor, of the University of Michigan; and "Influence of Environmental Factors on Smut Infection in Wheat Species," by F. N. Briggs, of the University of California at Davis.

The third symposium, "Growth-promoting Substances," was arranged by Dr. H. M. Evans, of the University of California. It included the following papers: "Growth Hormones in Plants," by F. W. Went, of the California Institute of Technology; "The Preparation and Chemistry of the Growth Hormone," by Dr. Thimann, of the California Institute of Technology; "The Growth Hormone of the Anterior Lobe of the Hypophysis," by M. E. Simpson, of the University of California; and "Relation of Glutathione Concentration to Growth," by H. Goss, of the University of California at Davis.

Dr. T. Wayland Vaughan presented one paper on "Recent Progress in Oceanographic Investigations of the Pacific and Present Trends of Marine Biological Research" and, in the absence of W. E. Allen and W. R. Coe, a second entitled "A Study of Fouling Organisms." Dr. A. E. Hopkins presented certain experimental observations on spawning and setting in the Olympia oyster. The morphological changes of sexual maturity in the salmon, the Alaska herring populations and mortality of the herring were discussed by Drs. F. A. Davidson, G. A. Rounsefell and E. H. Dahlgren, respectively, all of the U. S. Bureau of Fisheries, Seattle.

Certain phases of the life history, morphology and physiology of some species of protozoa were discussed in a series of papers presented by Drs. H. W. Graham, G. H. Ball, A. G. R. Strickland and M. G. Brown, respectively. Dr. Wm. A. Hilton discussed the ratio of nervous tissues to body tissues in a variety of forms. The evidence for the development of ligaments from muscles in the pocket gopher was presented by Mr. J. E. Hill. The antagonistic action of methylene blue to the action of certain respiratory poisons, as determined from experiments on marine eggs, was discussed by Dr. M. M. Brooks. A report on the determination of the non-solvent volume of marine eggs was given by Dr. J. L. Leitch. Dr. A. C. Giese reported on some experimental studies on the factors inducing conjugation in Paramecium. The relation of the redox potential of cell suspensions to cytochrome was discussed by Dr. J. P. Baumberger. Dr. L. R. Blinks presented some bioelectric measurements made on plant cells.

Besides the above papers the following were read by title only: "The Spawning Behavior of the Little Redfish, *Oncorhynchus nerka,* with Notes on Related Species of Salmon," by L. P. Schultz; "Growth Curves of Protozoan Population in Sterile Medium," by Austin Phelps; and "Experimental Studies in Motivation of Sex Behavior in Rats," by C. P. Stone.

Microcinematographs of micrurgical technique and experiments and of cells in the microscope centrifuge

were shown at one evening meeting. The society was indebted to Professor Robert Chambers and Professor E. Newton Harvey for the use of these films. After the society dinner, Dean Charles B. Lipman, of the University of California, delivered the principal address of the meeting, "The Tolerance of Extreme Temperatures by Plants."

JAMES L. LEITCH

THE HISTORY OF SCIENCE MOVEMENT IN WASHINGTON, D. C.

WHEN the History of Science Society meets in Washington, D. C., during the coming Christmas season of 1934 to celebrate its tenth anniversary, it will also celebrate the first anniversary of what may be termed its first offspring, the Washington-Baltimore Section of the History of Science Society. The parent society was organized in Boston, Mass., on January 12, 1924, and it is an interesting coincidence that on January 10, 1934, nearly ten years to a day later, the first local section came into being. On that day a small group of members of the History of Science Society met at the Cosmos Club in Washington to discuss the advisability of meeting informally to foster our common interest, stimulate activity in the movement and study of the history of science and to entertain distinguished scholars and students of our subject who may from time to time visit our city.

Present at this meeting were Dr. C. A. Browne, chief of the U. S. Bureau of Chemistry and Soils; F. E. Brasch, secretary-treasurer of the History of Science Society; Dr. J. F. Couch, Bureau of Animal Industry; Dr. C. L. Shear, Bureau of Plant Industry; Watson Davis, director of Science Service; Dr. S. F. Bemis, department of history, George Washington University; O. A. Morgner, bibliophile; R. LeGear and M. C. Leikind, of the Library of Congress.

An informal organization was agreed upon and Dr. J. F. Couch and M. C. Leikind were elected chairman and secretary, respectively. In view of the fact that about forty members of the History of Science Society are distributed between Washington and Baltimore it was decided to call this section the Washington-Baltimore Section. The first regular meeting took the form of a dinner in honor of George Sarton, research associate of the Carnegie Institution of Washington and editor of *Isis*. Thirty-eight members, including a delegation from Baltimore, were in attendance at this most successful meeting, which was held in the Cosmos Club on the evening of January 27.

The list of guests and speakers included, besides Dr. Sarton, Dr. John C. Merriam, president of the Carnegie Institution of Washington; Sir Henry Wellcome, of London, England, founder of the Wellcome Museums in the History of Science and Medicine; Professor Henry E. Sigerist, director of the Institute of the History of Medicine of the Johns Hopkins University; Dean Dorothy Stimson, of Goucher College; Dr. Fielding H. Garrison, librarian of the Welch Medical Library, and Dr. C. A. Browne, chief of the U. S. Bureau of Chemistry and Soils.

The response and interest shown at this first meeting was so enthusiastic that we hope our example may serve as a stimulus for the formation of similar groups in other cities. It is by the organization of local chapters which will meet at frequent intervals during the year that the real influence of the History of Science Society will begin to assert itself.

The growth of the History of Science movement is indicative of the fact that history is no longer the exclusive domain of the social scientists and philosophers. The importance of the history of science as one of the foundation pillars in the history of civilization and culture is being given increasing recognition not only by individual scientists and scholars but by the curriculum making bodies of colleges and universities.

At a time when extreme specialization seems to be destroying the cultural and humanitarian aspects of science, the field of the history of science provides the one meeting ground where students of special sciences may meet and talk a common tongue. For, to quote Dr. Sarton, "The history of science is the history of mankind's unity, of its sublime purpose, of its gradual redemption."

We of the Washington-Baltimore Section hope that when the History of Science Society meets in Washington at the end of the year we shall be only one of a large number of local sections.

MORRIS C. LEIKIND,
Secretary, Washington-Baltimore Section, History of Science Society
LIBRARY OF CONGRESS
WASHINGTON, D. C.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A RAPID METHOD FOR THE PREPARATION OF DELAFIELD'S HAEMATOXYLIN

THE usual procedure in preparing Delafield's Haematoxylin requires a long ripening period. This ripening may be reduced from sixty days to three hours by use of the method described in this paper.

Delafield's Haematoxylin was prepared in the usual manner:

Haematoxylin crystals	4 gms.
Alcohol 95 per cent.	25 cc
Sat. sol. of ammonia alum	400 cc

This solution was placed in an open dish, at a distance of 15 cms from a Cooper-Hewitt burner, operating at 140 volts and 3.3 amperes, for one hour. The solution was then filtered and to the filtrate was added:

Methyl alcohol	100 cc
Glycerine	100 cc

This solution was placed under the Cooper-Hewitt burner at the same distance for two hours. The solution was then filtered and used for staining purposes.

No appreciable difference was noticed between the staining quality of the Haematoxylin prepared in this manner and that left for sixty days to ripen.

H. W. NEILD

UNIVERSITY OF ILLINOIS

SOAP AS A MOSQUITO LARVICIDE

DURING some experiments with mosquito larvicides the writer has observed that the addition of soap has brought about a much larger increase in toxicity to mosquito larvae than that which could be ascribed to improved penetration. This suggested that soap may possess direct toxicity to mosquito larvae. To verify this point tests were carried out with a liquid soap, consisting of a mixture of potassium oleate and cocoanut oil soap containing about 40 per cent. actual soap.

For this purpose larvae and pupae, taken from a partially polluted ditch breeding primarily *C. pipiens,* were transferred to large porcelain dishes containing about 500 cc of a mixture of tap water and ditch water. Various concentrations of soap were then mixed in. After 24 hours the number of dead and living insects were counted.

The results, given in the accompanying table, clearly show that concentrations of 0.2 per cent. soap or higher gave 100 per cent. kill of larvae and pupae.

The value of soap as a larvicide can perhaps be utilized in treating clear standing water, fire barrels, etc., where application of oil or larvicides containing toxic or inflammable chemicals are objectionable.

TOXICITY OF SOAP TO MOSQUITO LARVAE AND PUPAE

Per cent. soap concentration	Number of larvae	Per cent. dead after 24 hours	Number of pupae	Per cent. dead after 24 hours
0.05	80	20	40	5
0.10	100	65	60	55
0.20	80	100	60	100
0.50	60	100	40	100
1.00	80	100	80	100
Check	100	0	60	0

JOSEPH M. GINSBURG

N. J. AGRICULTURAL EXPERIMENT STATION

FIXING THE PRINT OF CARBON COPIES

THE tendency of the print to become smudgy in use in bound copies of dissertations, etc., may be almost entirely eliminated by a simple treatment, that is, of melting the colored wax of the print by heat into the fibers of the paper. This may be accomplished by passing a tall Bunsen flame rapidly over the surface of the sheet. The paper should be lying flat on a smooth, good-conducting surface while flaming. After such a heat treatment the sheets are somewhat warped but may be readily flattened out in a good binder's press.

ALDEN F. ROE

THE GEORGE WASHINGTON UNIVERSITY SCHOOL OF MEDICINE

SPECIAL ARTICLES

DEUTERIUM OXIDE AND ASPERGILLUS

RECENT investigations seem to indicate that deuterium oxide in high concentrations exerts a toxic or inhibitory effect on living organisms, both plant and animal. However, as a result of his work with *Spirogyra sp.,* it was suggested by Barnes[1] that very unusual and interesting effects might be noted when the deuterium was used in less concentrated solutions. This suggestion has received confirmation and support by Richards,[2] whose observations on the growth of *Saccharomyces cerevisiae* indicate that, in dilute concentrations, deuterium may have a decided effect in accelerating growth and development as opposed to its pronounced lethal effect in high concentrations. Macht and Davis,[3] using a solution of one part deuterium to two thousand parts of protium, expressed

[1] T. C. Barnes, "A Possible Physiological Effect of the Heavy Isotope of H in Water," *Jour. Am. Chem. Soc.,* 55: 4332–4333, 1933; "Further Observations on the Physiological Effect of the Heavy Hydrogen Isotope on Spirogyra," *Am. Jour. Bot.,* 20: 681–682, 1933.

[2] O. W. Richards, "The Growth of Yeast in Water Containing Deuterium," *Am. Jour. Bot.,* 20: 679–680, 1933.

[3] D. I. Macht and M. E. Davis, "Some Pharmacological Experiments with Deuterium," *Jour. Am. Chem. Soc.,* 56: 246, 1934.

doubt that any very remarkable effects would be forthcoming from the use of dilute solutions.

In this connection, the writer felt that it might be interesting to determine the effect of a dilute solution of deuterium oxide upon the growth of a fungus, *Aspergillus sp.* This organism has been found to be extraordinarily sensitive to differences in the culture medium (Mann[4]) and so might be expected to reflect in its growth and fruiting any changes brought about by the presence of the isotope of hydrogen.

A sample of deuterium oxide containing one part deuterium to 213 parts protium, approximately a .47 molecular per cent. solution, was obtained from the Ohio Chemical and Manufacturing Company at Cleveland. This water was distilled in order to remove any impurities present. After distillation, the relative density of the heavy water referred to ordinary water, both at 20° C., was 1.0019.

The nutrient solution used in these experiments was Pfeffer's three-salt solution, with sucrose as the source of carbon. Two groups of nutrient solutions were prepared, one with double-distilled H^1H^1O; the other with distilled H^2H^2O. The nutrient medium was placed in 150 cc Erlenmeyer flasks, 50 cc to the flask. The solutions were sterilized by streaming steam for a period of twenty minutes on each of three successive days. Inoculations were made from a pure, bacteria-free culture of *Aspergillus sp.* on bread by means of a platinum loop. The fungus was grown in an incubator for five days at a temperature of 37° C. The mycelial felts were then removed from the flasks, placed on weighed filter paper and dried for three days at 65° C. The filter paper used had been previously dried at the same temperature and placed in a desiccator. At the end of the three-day period, the felts were removed from the drying oven, placed in a desiccator and then weighed. From the total weight of the felt and the filter paper was subtracted the weight of the filter paper alone. Thus it was possible to determine and compare the weights of the felts grown in the deuterium oxide medium with those grown in that of protium oxide.

The fungus grown in the H^1H^1O Pfeffer's medium was in the form of a flat and evenly fruited felt. The average weight of the felts from four flasks of this solution was .0481 grams. The felts grown in the heavy water medium exhibited every indication of stimulation. They were markedly convoluted and cratered below, resembling a brain-coral; the fruiting was greatly diminished, and the distribution of spores on the surface of the felts was irregular and occurred in localized regions. When the dry weights of these heavy water felts were taken, it was found that the average weight from the four flasks was .7719 (see Table I), or approximately sixteen times that of the felts grown in the ordinary distilled water medium.

TABLE I*

Series	Weight of filter paper	Weight of filter paper and felt	Weight of felt
1 a	1.3544 gr.	1.3963 gr.	.0419 gr.
1 b	1.3490 gr.	1.3994 gr.	.0504 gr.
1 c	1.3511 gr.	1.3983 gr.	.0472 gr.
1 d	1.3593 gr.	1.4123 gr.	.0530 gr.
Average weight of felt = .0481 grams.			
2 a	1.3592 gr.	2.1400 gr.	.7808 gr.
2 b	1.3722 gr.	2.1940 gr.	.8218 gr.
2 c	1.3681 gr.	2.0724 gr.	.7043 gr.
2 d	1.3442 gr.	2.1250 gr.	.7808 gr.
Average weight of felt = .7719 grams.			

*Series 1—Pfeffer's Three-Salt Solution + Distilled H^1H^1O.
Series 2—Pfeffer's Three-Salt Solution + Distilled H^2H^2O.

The writer, therefore, is of the same opinion as Barnes and Richards, that deuterium, when used in dilute concentrations, may have a decided effect in stimulating vegetative growth and development. Further experiments in this connection are planned and a more detailed consideration of the methods used and the results obtained will be published later.

SAMUEL L. MEYER
VANDERBILT UNIVERSITY

THE EFFECT OF FERRIC CHLORIDE INJECTIONS IN EXPERIMENTAL TUBERCULOSIS[1]

SEVERAL years ago the writer showed that repeated intravenous injections of a 0.25 per cent. ferric chloride solution were followed by an accumulation of iron in caseous areas of the lungs of tuberculous rabbits.[2,3] Concomitantly with this accumulation of iron, the life span of infected animals was found considerably increased over that of control tuberculous rabbits that had received no injections of the ferric salt solution. This was found to be the case in two entirely independent series of experiments comprising 36 rabbits.[4,5] Furthermore by comparing tuberculous lesions of both experimental and control animals sacrificed at various intervals of time, it was shown that following the intravenous injections of ferric

[4] M. L. Mann, "Calcium and Magnesium Requirements of *Aspergillus niger*," *Bull. Torrey Club*, 59: 443–490, 1932.

[1] From the Department of Pathology, Harvard Medical School, Boston, Mass. Aided by a grant from the DeLamar Mobile Research Fund.

[2] V. Menkin, *Proc. Soc. Exp. Biol. and Med.*, 27: 1020, 1930.

[3] V. Menkin and M. F. Menkin, *Jour. Exp. Med.*, 53: 919, 1931.

[4] V. Menkin, *Jour. Exp. Med.*, 55: 101, 1932.

[5] V. Menkin, *Am. Jour. Med. Sci.*, 185: 40, 1933.

chloride, the progress of the lesions was retarded in their extent.[5] The conclusion drawn was that ferric chloride protracted the course of bovine tuberculosis in the rabbit. Subsequent studies revealed the fact that subcutaneous inoculation of tubercle bacilli followed by an immediate course of intravenous injections with dilute ferric chloride solution retarded the dissemination of the organisms, as evidenced by the degree of tuberculous involvement in the various organs.[6]

These studies have been continued and form the subject of this brief communication. A more detailed account of the following observations will appear in a subsequent report. Ten rabbits were each inoculated intravenously on November 8, 1932, with 0.005 mgm of a relatively avirulent strain of bovine tubercle bacilli (Strain Cernay, obtained through the kindness of Dr. A. Boquet from the Pasteur Institute). On December 22, 1932, each one of these 10 rabbits was inoculated subcutaneously in the thigh with 0.05 mgm of a virulent bovine Ravenel strain of tubercle bacilli. Repeated intravenous injections with 0.25 per cent. ferric chloride solution were immediately started in 5 of the rabbits; the remaining tuberculous animals were kept as controls. The ferric chloride injections were carried on for about 15 weeks and then discontinued. The first control rabbit died 47 days after reinfection with tubercle bacilli. On May 1, 1933, 130 days after reinoculation with the bacilli, the last of the controls was found dead. Practically all these 5 control animals displayed at autopsy wide-spread confluent tuberculous lesions, affecting primarily the lungs, with discrete tubercles in the kidneys, and with prominent tuberculous abscesses at the site of subcutaneous reinoculation. The average survival time of the control group was 81.4 days.

The first experimental rabbit died 81 days after reinoculation; the second died on the 110th day; and the third one succumbed 131 days after reinfection with tubercle bacilli. Two of these three animals had an upper respiratory infection at the time of death. All three rabbits revealed discrete caseous tubercles in the lungs, with hardly any confluence of lesions. The two remaining animals continued to increase in weight for over 6 months after the death of the last control. On November 21, 1933, 334 days after reinoculation with tubercle bacilli, these two rabbits were killed, and Professor S. B. Wolbach very kindly performed the post-mortem examinations. One of these two animals showed absolutely no sign of any lesion in the thigh. This fact, though somewhat surprising, is not wholly incomprehensible when it is recalled that Lurie recently failed to find in some rabbits any trace of local lesions about one year following subcutaneous inoculation with human tubercle bacilli, whereas in other animals he found large well-walled-off tuberculous abscesses.[7] Near the base of the lungs two large tuberculous foci were found, one of which formed a pus pocket in which tubercle bacilli swarmed in abundance. These lesions were well walled-off by connective tissue proliferation. The other rabbit, which had just begun to show slight loss in weight at the time that it was killed (334 days after reinoculation with tubercle bacilli), revealed at autopsy somewhat more tuberculous involvement. In the thigh at the original site of subcutaneous inoculation there was found a prominent well-encapsulated tuberculous abscess containing a thick viscous creamy purulent exudate, in which were found numerous tubercle bacilli. Throughout the lungs were scattered a number of discrete tuberculous foci with no confluence of lesions. On microscopic examination the areas of caseation in these tubercles were found to be relatively small in comparison with the peripheral cellular infiltration. The extent of tuberculosis was considerably less than in the controls, the last of which had died more than 200 days previously. The spleen of this experimental animal revealed a single large caseous focus. The left kidney showed considerable caseous involvement of the cortex and medulla with the process extending to the pelvis and the proximal portion of the left ureter. A few discrete tubercles were found in the intestinal tract primarily in the region of the cecum.

The average survival time of the experimental group is unknown, since two of the animals were finally sacrificed. However prior to the autopsy of the two experimental survivors the average life span of this group of rabbits was 198 days, as compared with 81.4 days in the control series. These observations are not only in complete agreement with the findings obtained in the previous and independent series of experiments,[4, 5, 6] but they reveal even more pronounced effects upon the course of tuberculosis in rabbits repeatedly treated with ferric chloride. In none of the previous experiments were there any tuberculous animals which survived in apparent good health, with consistent gain in weight for a period of over 6 months after the death of the last of the controls. It remains to be seen whether this sharper retardation in the development of tuberculosis is entirely due to the ferric chloride injections or whether it may be due in part to the combined effects of a superimposed initial vaccination. Studies now under way in a series of non-reinfected tuberculous rabbits seem to show that primary infection with an avirulent strain of bacilli probably plays only a rela-

[6] V. Menkin, *Proc. Soc. Exp. Biol. and Med.*, 30: 951, 1933.

[7] M. B. Lurie, *Jour. Exp. Med.*, 58: 305, 1933.

tively minor rôle in delaying the progress of the disease induced by reinfection with a virulent strain. The more striking results in regard to longevity and progress of tuberculosis obtained in the present series of experiments as compared to previous series are perhaps referable to various other factors, including route of virulent tubercle bacillus inoculation, *i.e.*, subcutaneous instead of intravenous, interval of time between inoculation and onset of intravenous ferric chloride injections, and finally, dose and virulence of bacilli employed. Experiments are now in progress in an attempt to answer these various questions. They will form the subject of a future communication.

VALY MENKIN

FROGS AND OPALINIDAE

CONCOMITANT studies of the taxonomy and geographical distribution of the Anura and their intestinal commensals, the Opalinidae, give indications of places and geologic times of origin and of the routes and times of spreading of all but one of the families of Anura, of some subfamilies and of several genera: and at the same time tell of the times and places of origin and of the routes and times of spreading of the Opalinidae, about 130 species of these Protozoa being included in the survey. A study of these problems has been in the hands of the editor for the United States National Museum since May, 1932, waiting only for the restoration of customary appropriation for printing. Such detailed study of origin and distribution has not been given before for any groups of animals. The data used are interwoven in intricate ways and are difficult to discuss without full description, but because of the unavoidable delay in publication it seems advisable to attempt the presentation of enough to show the kinds of data used, the methods of using them to bring out their significance and to illustrate the extent of the conclusions reached.

The data are: Present geographical distribution of the species and groups of Anura and of the species and groups of Opalinidae; the host distribution of Opalinidae; the taxonomic relationships of the groups of Anura; the interrelationships in detail of the Opalinidae, which show from their anatomy and their life-histories the course of their evolution in great detail; the agreement of present-day distribution of hosts and parasites with ideas of former intercontinental land connections and also seas, as commonly postulated by students of paleocartography.

It is of interest that the almost complete absence of paleontologic record of the Anura does not prove an insuperable bar to such evolutionary and paleodistributional studies. Evidence from the other sources mentioned proves adequate for profitable study and indicative of far-reaching conclusions.

The chief paleocartographical data used in these studies are: A Triassic continent, Gondwanaland plus South America (though the connection between Africa and South America may have been by way of Antarctica); a separation of Australasia from Malaysia, persisting since early Cretaceous times; Tertiary fluctuations in the Malaysian island connections, both with one another and with extra-Malaysian lands, which may have given brief connection between Papua and the southeastern Malaysian islands; a Cretaceous arm of the sea connecting the western Gulf of Mexico with the Arctic Ocean; a Cretaceous land strip from eastern Asia, running south of Alaska and down parallel to the western American coast and extending certainly to Central America and probably for a time to Ecuador or even to Chile (Tertiary connection of this strip was established with North America proper by the obliteration of the Gulf of Mexico-Arctic Ocean strait, and at the same time the southern portion of the land strip disintegrated); a Cretaceous or early connection of central or northern South America with Papuasia and Australia through the central Pacific islands; a bar to migration between southern Brazil and Patagonia, probably an arm of the sea or a strait, present in Cretaceous times or a little later and disappearing during the Tertiary, probably about the middle Miocene; an extended Antarctica, uniting Australia, New Zealand, Patagonia, sub-Antarctic islands in both Eastern and Western Hemispheres, and possibly Africa, the South American connection disappearing before the trans-Argentine sea was obliterated—Greater Antarctica was probably Cretaceous and persisted during the early Tertiary; an Indian Ocean continent, Lemuria, uniting Africa, Madagascar, Ceylon, southernmost India, the islands southwest of continental Malaysia and probably some of the southwestern Malay Archipelago islands (Lemuria existed in the Triassic, broke off from Africa during the Jurassic, and broke into separate islands before the end of the Tertiary). The data, discussed in the National Museum paper mentioned, agree with these paleocartographic conceptions, except for a single indication, namely, that there was a brief Tertiary connection between eastern Lemuria and continental Malaysia.

Let us note illustration of the handling of data in these studies. The Bell-toads evolved before the Cretaceous, since their spreading was not prevented by the Cretaceous separation of Australasia from Asia, they being present to-day in both Euro-Asia and New Zealand. They spread: North and west to Europe, where they are now represented; north and east to northern China (they are now present near the base of the Korean peninsula); south and east across Australia, where they left some of their characteristic

Protoopalinae of subgeneric group II, and on to New Zealand, this migration from Asia to New Zealand being as early as the early Cretaceous period or earlier, for the route was interrupted later than this. They passed from northeastern China on north and east by way of the land strip connecting Asia with the Western Hemisphere, during the Cretaceous period when this route was in existence. By the Tertiary time, when the land strip fused with continental North America, they had deteriorated in vigor and did not spread beyond western portions of Washington, Oregon and California, which were parts of the land strip. One Bell-toad is still found near the eastern Himalayas, the probable place of origin of the family. Two very decadent representatives of this decadent family are found at the extreme northeastern and southeastern limits of the range of the family: *Ascaphus,* a retiring form, confined to western Californian and Washington mountains, where it lives near the edge of glaciers, and *Liopelma,* in similar habitat in New Zealand. Though *Liopelma* has now lost its larval stage, its eggs hatching under stones in young adult form, and so, of course, showing no Opalinids, which can infect only aquatic tadpoles, the ancestors of *Liopelma,* then in less degenerate condition when they were crossing Australia, had aquatic tadpoles and characteristic Bell-toad *Protoopalinae* of subgeneric group II, through which they infected Australian frogs of other families, as found to-day. The places and times of origin and the routes and times of spreading to Australia of these secondary hosts are indicated in the fuller paper.

Another example of the use of data: *Cepedea* developed from *Protoopalinae* of subgeneric group VIII, which show transition to the multinucleate condition of *Cepedea.* They developed in Asia-Malaysia (where these *Protoopalinae* are alone found) in *Rana,* and spread to eastern Lemuria in the early Tertiary, both *Rana* and *Cepedea* being abundant in Madagascar, the Seychelles and Ceylon. *Rana* did not carry *Cepedea* via the Pacific land strip to North and South America. They evolved too late, after this route was lost. *Rana* did cross from Siberia to Alaska with *Cepedea* during the Tertiary, and both hosts and parasites have become abundant in North America, evolving many species. *Rana* and not *Bufo* was the early host in which *Cepedea* evolved and passed to Lemuria, as is indicated by the complete absence of *Bufo* from Lemurian lands to-day.

Opalina, a flattened, multinucleate genus, did not evolve from *Zelleriella,* a flat, binucleated genus, as it seems it might well have done by merely acquiring multinucleation. This is indicated by the fact that *Zelleriella* and *Opalina* do not occur and never have occurred in the same locality. *Opalina* arose from *Cepedea* by flattening; where and when involves complicated reasoning.

Similar indications as to times and places of origin and spreading of every family (except the Gastrophrynidae), of many subfamilies and genera and of a goodly number of species of Anura, and of every genus and numerous species and groups of species of Opalinids, can be found in the available data, in spite of such lack of fossils as would at first thought make these groups seem especially unfavorable for study.

The agreement of the conclusions as to the frogs and Opalinids with the generally postulated hypotheses of paleocartography is a striking evidence of the probable correctness of these hypotheses. An exception is in the presence of *Rana* and *Cepedea* in Lemurian lands, which has necessitated uniting eastern Lemuria and Asia-Malaysia, perhaps briefly, in the Tertiary.

The data used are varied, abundant and for the most part unquestioned, except the paleocartography. But with groups of parasites in which the course of their evolution is less assuredly indicated than it is with the Opalinidae a great aid to this type of study would be wanting. With the frogs and Opalinids it is like putting together a dissected picture puzzle of very many pieces. But when the pieces (data) finally fall into place, they make a consistent and convincing picture.

As this little paper is designed to emphasize the value and workability of the method of study, perhaps enough has been said without listing more of the many conclusions and indications found. That must be left for the fuller paper.

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CASTIGLIONI, ARTURO. *The Renaissance of Medicine in Italy.* The Hideyo Noguchi Lectures. Pp. xiv + 91. Johns Hopkins Press. $1.50.

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